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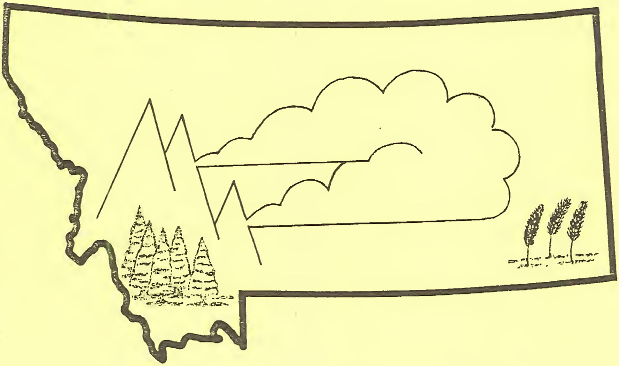
Determination of minimum instream flows, sediment discharge, and stream channel formation related to the balance of natural maintenance and preservation of fishery/wildlife habitat and manipulation of the Poplar River by man.



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POPLAR RIVER INVESTIGATION

Determination of minimum instream flows, sediment discharge, and stream channel formation related to the balance of natural maintenance and preservation of fishery/wildlife habitat and manipulation of the Poplar River by man.

INTRODUCTION

Many considerations are utilized to estimate flows by means of stream channel geometry and morphology. Measurements are based on channel bankfull stage or the point of overflow onto the floodplain.

Stream channel Geometrics and Morphology Considerations

1. Flow reliability and discharge characteristics
2. Bank and bed material (substrate)
3. Substrate particle size
4. Channel and floodplain slope (elevation variation)
5. Channel profile (width, depth, area)
6. Vegetation
7. Channel scouring and bedload capacity
8. Normal wetted channel profile
9. Channel barriers
10. Timing and duration of runoff

A relationship between flushing flows, suspended sediment, channel scouring, substrate particle size, and existing channel morphology is a major goal of this survey. Because deposition may be detrimental to wildlife habitat and affect spawning activities, flushing of the Poplar River is recommended prior to spawning to avoid disturbance of fertilized redds.

Physical Observations

The Poplar River channel is formed by seasonal flow fluctuations undercutting banks creating sluffing conditions, mass erosion, and wide shallow bends. Deep cuts are prevalent on outside bends, and wide shallow plains dominate the physiography of inside bends. Seasonal runoff fluctuations enhance erosive conditions and increase loads. Spring runoff volumes vary a great deal depending on snowpack, soil saturation, spring rains, and temperature. The flatness of terrain maintains low flow velocities. Braided and long pool -- short riffle conditions are found throughout the river system.

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ditions are found throughout the river system.

Soil regimes consist of 0-3.0 feet of silty, sandy loams underlain by a deep glacial till. Most stream reaches are cut into the glacial tills layer.

Larger discharges are capable of scouring greater stream stages depending on the width of the established channel. Resistance to scouring occurs at a point where discharge limits cannot handle large particles or when substrata such as bedrock becomes a factor. Floodplains and lower velocity (slope dependent) greatly affects scouring efficiency. Characteristics of the Poplar system indicate that larger, heavier particles from glacial till regimes are deposited within an area of local velocity movement which may account for the dominance of gravels as a substrate throughout most of the river system. Lighter silty/sandy materials are washed downstream and deposited when critical load carrying capacity is dissipated. Generally these lighter materials were found as substrate in downstream reaches of long pools.

Survey Sites

Ten representative sites were selected for stream channel geometric surveys. These sites were coordinated as much as possible with study areas utilized in Fish and Game fishery studies. The following table indicates the location of these sites.

Table I. Poplar River Stream Channel Geometry Study Sites

Fork and Site	Legal Description	River Location
East Fork		
2.5 miles below International Border	SW¼ SW¼ Sec. 8 T36N, R48E	Upper
Cromwell Slab	NW¼ NE¼ Sec.14 T36N, R48E	Middle
USGS gage at Hwy. 13 (06179000) near Scobey	NE¼ NW¼ Sec.27 T36N, R48E	Lower
West Fork		
South of Peerless	NW¼ SE¼ Sec.16 T34N, R45E	Upper
Susag Farm	SW¼ SW¼ Sec. 2 T32N, R48E NE¼ NW¼ Sec.11 T32N, R48E	Lower
Middle Fork		
McCarty Crossing	SW¼ NW¼ Sec.16 T36N, R46E	Upper
Hagfeldt Slab	NW¼ SW¼ Sec.36 T36N, R47E	Middle
Ofstedal Slab	SW¼ SW¼ Sec.18 T36N, R48E	Lower

Table I (continued)

Fork and Site	Legal Description	River Location
Main Stem		
Paulsen Slab	SW¼ SW¼ Sec. 4 T32N, R49E	Above WF
Crowley Slab	SE¼ SW¼ Sec.27 T31N, R50E	Below WF

A detailed description of each study site is found in the appendix.

The general consensus of the Poplar River system is as follows: The variance of slope between floodplain, bankfull stage and normally wetted channel is very slight. Surveying indicated that slopes are less than 0.1% which contributes to meandering conditions and slow velocities. The substrate/vegetation ratio indicates approximately 35-40% of the channel is covered by various vegetation species at bankfull stage. Runoff generally occurs between March 20 and April 15. During this time, the ground is semi-frozen but saturated. Springs are prevalent and ice jams contribute to local flooding. Runoff generally peaks quickly and gradually tapers off to base flows around July 15.

Historical records from USGS gaging stations at the International Boundary (06178000) indicate that the Middle Fork may flow over 1000 cubic feet per second during most runoff periods. The extreme discharge was recorded at 12,700 cfs. The East Fork recorded a peak of 3020 cfs at the International Boundary (06178150) which is unlikely to repeat unless releases and spills from the Canadian dam are available.

Very little debris was noted in the channel other than sluffing bank material at isolated locations. Cutting action on outside banks during high flows is great because bank materials are very unstable when soil moisture is high. The saturation of porous bank layers quickly create sluffing and oozing situations, thus removing of light silty materials in the form of suspended sediment and heavier gravel deposition.

Most sediment is deposited throughout the river system during later stages of the runoff period. It is doubtful that flows exceed velocities of 1.5 feet per second in most areas. Extreme velocities may reach 2-3 feet per second under ideal conditions for short distances, but quickly dissipate in pool areas. Peak discharges are capable of carrying most of the lighter materials into the main Poplar and downstream to the Missouri. Riffles were fairly clean of silt in most of the cross-section study sites. Lower portions of some long deep pools contain over 1.0 feet of silt and sand substrata depending on inlet flow patterns and scouring frequencies. Shifting of gravel bars and local bank erosion is common on all of the Poplar Forks, therefore, riffle scouring should be accomplished by natural spring runoff.

Suspended Sediment

Suspended sediment and bedload/substrata samples were analyzed to determine the type and approximate quantity of sediment presently found in the

stream during channel formation periods.[1]

Table II interprets the suspended sediment data in milligrams per liter and tons per day on the East Fork. Note the increase in tonage transported at sequential downstream sites.

Table II. East Fork Poplar River Total Suspended Sediment Analyses

	2.5 Miles Below International Border			Cromwell Slab			USGS gage at Hwy. 13 near Scobey		
Date	Mg/l	cfs	tons/day	Mg/l	cfs	tons/day	Mg/l	cfs	tons/day
3/14	----	4.3	----	----	75	----	59.6	197	31.6
3/15	51.0	3.5	0.48	42.9	75	8.7	----	197	----
3/20	44.5	3.0	0.36	25.1	75	5.1	45.2	197	23.9
3/21	48.9	2.7	0.36	39.9	75	8.0	61.3	197	32.5
3/22	53.2	3.0	0.43	57.4	75	11.6	54.2	197	28.7
3/23	30.9	3.7	0.31	54.7	75	11.0	36.5	197	19.3
3/24	85.4	4.5	1.03	34.0	75	6.9	64.9	197	34.4
3/27	17.2	6.9	0.27	24.6	75	5.0	44.6	197	23.6
3/28	14.0	5.0	0.19	22.2	75	4.5	37.9	197	20.1
3/29	15.9	3.7	0.16	42.0	75	8.5	39.2	197	20.8
3/30	28.0	3.9	0.29	21.8	75	4.4	54.2	197	28.7

Discharge near the International Border on the East Fork most certainly affects the amount of suspended material transported through local stream reaches. Sediment loads and runoff volumes increase as the drainage area increases below the East Fork dam as indicated at Cromwell Slab and near Scobey.

Table III interprets suspended sediment data collected on the Middle Fork, Note the tonage increase sequentially downstream.

TABLE III. Middle Fork Poplar River Total Suspended Sediment Analyses.

	McCarty Crossing*		Hagfeldt Slab*		Ofstedal Slab		
Date	mg/l	tons/day	mg/l	tons/day	mg/l	cfs	tons/day
3/15	20.4	2.5	36.1	4.5	20.4	46	2.5
3/20	48.9	93.0	65.5	124.6	66.5	707	126.5
3/21	100	187.5	113	211.9	139	697	260.6
3/22	104	132.6	172	219.3	314	474	400.4
3/23	45	32.8	72.2	52.6	124	271	90.4
3/24	33.4	26.6	49.4	39.3	88.6	296	70.5

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[1] Suspended Sediment calculated in tons/day $= \frac{\text{lbs/day}}{\text{2000 lbs/ton}} = \text{mg/l} \times \text{cfs} \times 5.38$

Table III (continued)

	McCarty Crossing*		Hagfeldt Slab*		Ofstedal Slab		
Date	mg/l	tons/day	mg/l	tons/day	mg/l	cfs	tons/day
3/27	82.6	160.4	160	310.7	202	722	392.3
3/28	26.2	35.8	157	214.5	204	508	278.8
3/29	21.3	26.7	49.1	61.5	120	466	150.4
3/30	20.3	29.5	46.8	68.1	98.6	541	143.4

*Discharge measurements estimated and compared to values utilized at Ofstedal Slab.

Table IV interprets West Fork and Main Stem Poplar suspended sediment data. Dilution by flow fluctuations on each fork affect tonage transport.

Table IV. Main Stem Poplar and West Fork Poplar Total Suspended Sediment Analyses.

	Paulsen Slab Above WF			West Fork near Susag Farm*			Crowley Slab Below WF		
Date	Mg/l	cfs	tons/day	Mg/l	cfs	tons/day	Mg/l	cfs	tons/day
3/16	31.6	146	12.4	10.6	455	13.0	44.9	601	72.6
3/20	51.4	807	111.6	30.2	455	37.0	78.2	1262	265.5
3/21	104	797	223	40.6	455	496.9	72.3	1252	243.5
3/22	227	574	350.5	60.9	455	74.5	134	1029	370.9
3/23	148	371	147.7	66.0	455	80.8	124	826	275.5
3/24	74.4	396	79.3	76.1	455	93.1	153	851	350.2
3/27	230	822	508.6	500	455	612.0	466	1841	2307.8
3/28	264	608	431.8	1200	1019	3289.3	608	1627	2661.0
3/29	276	566	420.2	186	1019	509.8	350	1585	1492.3
3/30	132	641	227.6	176	1019	482.4	208	1660	928.8

*Discharge estimated based on upstream records.

Flushing Action

Flushing flows are necessary to induce critical erosion velocities, the minimum velocity of which a particle of given size, loose on the bed of a channel will move.

Flushing action is affected by:

1. Vegetation/substrate ratio
2. Mean basin elevation
3. Discharge quantity
4. Runoff timing
5. Runoff duration

6. Water Temperature
7. In-channel barriers
8. Velocity

Hypothetically, a stream with a mean velocity of 1.91 feet per second may be capable of transporting particles of 10.0 millimeter or less in diameter. At this velocity, fine suspended particles would move at the same speed as water. If a flushing duration lasted for 3 days, these particles could travel as far as 94 miles. This situation is highly unlikely to occur naturally in the Poplar River system because turbulence and pooling effects would decrease the stream's ability to transport materials. The implication is that the potential for movement of large quantities of fine suspended materials over long distances exists even when velocities are very low.[1]

Water temperature is an important factor affecting transport of heavier, coarse sediment. Viscosity and molecular cohesion of fluids directly affect the fall velocity or dropout point of particles. At lower temperatures, fall velocity is decreased especially for fine and medium sandy materials. The lower the temperature, the longer particles can remain in suspension.[2]

Channel Scouring

Flushing action and flow frequencies are the main sources of hydrologic energy for maintenance of existing channel conditions. Surveys on major forks of the Poplar provide meaningful comparisons for calculating tractive forces necessary to entrain particles responsible for scouring streambeds. Larger particles move only at critical velocities.

The size distributions of bed materials were calculated from bedload samples collected in pools and riffles. From these size distributions, a minimum tractive force required to move the various particle sizes was determined. Table V indicates the bed material distributions of samples collected within the study sites. Samples were analyzed by the USGS Regional Office in Denver and are interpreted as follows:

Sample Location	Pool(P) Riffle(R)	D_5 mm*	D_{16}** mm	D_{35} mm	D_{50} mm	D_{65} mm	D_{84} mm	D_{95} mm
East Fork Int. Border	P	3	8	11	16	40	65	84

*Diameters expressed in millimeters

**Diameters expressed in percentages (%) eg. D_{16} = 16% of the representative material is 8 mm in diameter or finer.

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[1] Hjulston, F., 1935, The Morphological Activity of Rivers, Hydraulics of Sediment Transport, Bull Geological Institute

[2] Guy, Harold P., 1970 Fluvial Sediment Concepts Book 3, Chapter C1 in Techniques of Water Resources Investigations of the USGS.

TABLE V. BED MATERIAL SIZE DISTRIBUTION

Sample Location	Pool(P) Riffle(R)	D_5 (mm)	D_{16} (mm)	D_{35} (mm)	D_{50} (mm)	D_{65} (mm)	D_{84} (mm)	D_{95} (mm)
East Fork								
2.5 miles below Inter. Border	P	0.058	0.095	0.11	0.15	0.18	0.25	0.4
	R	0.6	4.0	12.5	21	31	39	45
Cromwell Slab	P	0.34	1.6	7.6	12.5	21	46	57
	R	2.7	10.25	20	36.5	52	73	84
USGS gage near Scobey	P	0.27	1.0	4.8	9.1	16.5	31	49
	R	0.5	1.8	8.5	14	22	39	49
Middle Fork								
McCarty Crossing near Int. Border	P	1.7	8	19	33	45	63	80
	R	2.7	11	21	33.5	39	49	58
Hagfeldt Slab	P	0.21	0.37	6.6	21	39	56	62
	R	0.92	8.3	18	26	45	54	58
Ofstedal Slab	P	0.18	0.255	0.30	0.345	0.44	0.79	1.20
	R	4.7	10.5	19.5	28	37	68	75
West Fork								
South of Peerless	P	0.35	4.3	10.0	15.5	20.5	39.5	54
	R	4.2	10.5	25.5	48	68	79	86
Susag Farm	P	1.4	10.0	30	40	51	66	68
	R	0.32	1.8	7.6	14	32	56	68
Main Stem	P	0.062	0.099	0.135	0.165	0.21	0.33	0.45
	R	0.31	1.4	8.0	15	22	41	48
Crowley Slab	P	0.54	0.086	0.128	0.196	0.31	0.38	0.45
	R	0.30	1.6	10.0	17	24	47	52

Bed material similarities exist throughout the river system and can be divided into three categories:

1. Riffle gravels
2. Pool gravels
3. Pool silts and sands

Excessive siltation problems may be indicated by the fine material detected in the pool reach at upper East Fork Study site. Future analysis may be warranted but releases from the dam may reduce speculated deposition.

To calculate critical velocities needed to transport suspended sediment and dislodge a portion of bed materials (scouring), an analysis of river capacity and reasonable discharge capability is warranted. According to the general literature, 40% to 60% of the categorically available material should be removed by a bankfull stage discharge over a reasonable flow duration. Bed material is fairly stable, so even under extreme flood conditions less than one-half of the available materials are moved. During normal flow conditions approximately 15% to 30% of the moveable substrata is dislodged.[1] Bank material is much more unstable than bed material due to particle-size distribution and conglomeration of materials.

Typically, sands and gravels require less velocity to initiate movement than finer silts and organic matter because molecular cohesion and crystalline structures affect deposition characteristics. To calculate velocities, representative slope surveys were taken for the wetted channel, bankfull stage, and floodplain at each study site. Each stage recorded slopes of less than 0.05%----virtually flat.

Table VI indicates the velocities required to initiate movement of representative sample materials. Note the difference in initiation velocities for finer silt particles (0.01 mm) and sand (0.1 mm).[2]

Table VI. Velocities Required to move Particles of a Given Size

Particle Size (mm)	Minimum Velocity (0.0328) ft./second	Representative Particle Sizes from Poplar Drainages (mm)
0.001	----	---
0.01	2.79	0.058
0.1	0.82	0.15
1.0	1.15	1.6
10	3.28	8
100	14.79	75
1000	----	---

Velocities required to move particle sizes ranging between 0.001 mm and 10.0 mm should be quite common throughout the Poplar drainage during natural

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[1] Hjulston, F., 1935.

[2] Morisawa, Marie, Streams, their dynamics and morphology, 1968, from Hjulston (1935).

runoff periods. When mass movement of smaller particles occurs extensive shifting, undermining, and displacement of larger materials should also take place.

To determine discharge sequences and quantity, flow frequency analyses were made utilizing historical flow records throughout the Poplar Basin. The following tables indicate flow frequencies and their probable return period based on Log-Pearson Type III analysis.

Table VII. East Fork at International Boundary

Discharge (cfs)	Return Period (yrs)
3389	1000.00
3244	100.00
3111	50.00
2905	25.00
2463	10.00
1949	5.00
948	2.00
128	1.11
9	1.01

Table VIII. Middle Fork at International Boundary

Discharge (cfs)	Return Period (yrs)
37684	1000.00
14391	100.00
10190	50.00
6995	25.00
3925	10.00
2301	5.00
840	2.00
189	1.11
58	1.01

Table IX. West Fork at International Boundary[1]

Discharge (cfs)	Return Period (yrs)
26327	1000.00
11168	100.00
7981	50.00
5433	25.00
2895	10.00
1549	5.00
420	2.00
44	1.11
5	1.01

[1] Significant data lacking.

Table X. Poplar River near Poplar

Discharge (cfs)	Return Period (yrs)
272983	1000.00
82533	100.00
54149	50.00
34360	25.00
17244	10.00
9216	5.00
2903	2.00
560	1.11
162	1.01

By comparing flow frequencies to particle size movement requirements, a discharge/velocity/particle size relationship can be estimated. Through particle size analyses and flow frequencies per local discharge availability, approximately 100 cfs is required to move particle sizes ranging between 2 mm. - 3.5 mm.; 1000 cfs would dislodge and transport particle sizes 6 mm. - 8 mm. diameter; 10,000 cfs would move materials 10 mm. - 23 mm.

Adequate flushing velocities can be calculated by utilizing the Manning-Chezy Equation for determination of velocities.[2]

$$V = \frac{1.486\ R^{2/3}\ S^{\frac{1}{2}}}{N}$$

where $R = \frac{\text{Cross-sectional area}}{\text{wetted perimeter}}$

S = Slope

N = Manning's N (roughness factor)[3]

Cross-sectional dimensions of the study sites provide values for R and S. Manning's N is estimated for gravels and sand/silt areas. Table XI estimates representative velocities and discharges per site utilizing physical parameters of local channel geometry at a reasonable channel depth.

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[2] Barnes, Harry H., Jr., Roughness Characteristics of Natural Channels, USGS Supply Paper, 1849.

[3] N estimated to be approximately 0.027 - 0.031.

Table XI. Estimated Velocities and Discharges per Stream Reach Utilizing Channel Geometrics.

Location	Velocity ft/sec. N = 0.031 Minimum	Velocity ft/sec. N = 0.027 Maximum	Discharge cfs
East Fork			
2.5 miles below Int. border	2.7	3.1	1044
Cromwell Slab	3.8	4.3	457
USGS gage near Scobey	3.8	4.4	879
Middle Fork			
McCarty Crossing	5.9	6.8	1549
Hagfeldt Slab	2.6	3.0	504
Ofstedal Slab	3.5	4.1	1332
West Fork			
Susag Farm	3.4	3.9	324
South of Peerless	4.3	5.2	552
Main Stem			
Paulsen	2.6	3.0	515
Crowley	4.4	5.1	3036

Estimated discharges and velocities are calculated as uniform throughout cross-sections. This generally does not occur under natural conditions due to irregularities of bed material, vegetation, channel shape, slope variances, and individual pool and riffle conditions. The numbers generated represent average discharges through a series of representative pools, runs, riffles, and bends within a given study area. Critical erosion velocities and discharges from the previous calculations indicate that the Poplar River is naturally capable of generating

sufficient energy to adequately scour most areas. The upper reaches of the East Fork will require supplemental releases from the dam to insure proper scouring because natural flows are restricted by the dam.

Conclusions

Compiling data in terms of suspended sediment production, bedload capacities, channel flushing, and scouring requirements, tractive velocities/particle size, flow distribution, and critical erosion discharges enable estimates to be made regarding the frequency and discharge quantity required to maintain suitable fishery habitat in the Poplar River.

From the existing data base, the East Fork of the Poplar River should adequately maintain its existing channel by natural phenomenon beginning below the area of the USGS gaging station at Hwy. 13 near Scobey. The drainage area at this point is large enough to sustain adequate spring runoff on a probable five year sequence. Discharge upstream from above the gaging area should be supplemented by dam releases with at least 100 cfs every five years to ensure maximum scouring and flushing of pools and backwater areas. Flushing duration and quantity is recommended to be 200 acre-feet/day for three to five days and should coincide with natural runoff patterns.

In addition, a released flow of 50 cfs or 100 acre-feet/day for at least three days is recommended yearly to remove suspended sediment deposits in riffles and pool inlets in the upper East Fork. This would insure cleansing of spawning gravels, prevent layered deposition over invertebrate habitat, and reduce botanical growth in the main channels.

Hopefully, the dam on the East Fork will improve fishery habitat downstream by creating a partial sediment trap. Maintaining adequate flows would be beneficial in sustaining environmental balances throughout the Poplar River system.

Presently the Middle Fork, West Fork and Main Stem of the Poplar River have experienced minimal development. Channel morphology is maintained by natural phenomenon.

Appendix

Physical characteristics of representative study sites in the upper Poplar River Drainage

East Fork Poplar River

Site	Data
2.5 miles below International Border	length of cross-section--------------1700' height of floodplain above channel--- 2.5' mean bankfull stage width------------ 90' mean flowing channel width----------- 90' mean depth at bankfull stage: pool---- 7' riffle-- 3.5' mean channel depth(water covered)---- 4.0' bankfull stage slope----------------- 0.0005% floodplain slope--------------------- 0.00% wetted channel slope----------------- 0.1% Substrata: pool - silt, gravel, riffle - silty loam, bank - silty loam, gravel, glacial till Ground cover - low sage grass
Cromwell Slab	length of cross section--------------2000' height of floodplain above channel--- 3.0' mean bankfull stage width------------ 127' mean flowing channel width----------- 45' mean depth at bankfull stage: pool---- 6.0' riffle-- 4.5' mean channel depth(water covered)---- 0.9' bankfull stage slope----------------- 0.0018% wetted channel slope----------------- 0.5% Substrata: pool - silt riffle - gravel bank - silty loam, glacial till Ground cover - scattered grasses
USGS gage at Hwy. 13 (06179000)	length of cross-section--------------2200' height of floodplain above channel--- 2.5' mean bankfull stage width------------ 134' mean flowing channel width----------- 110' mean depth at bankfull stage: pool---- 12' riffle-- 4.5' mean channel depth(water covered)---- 1.6'

Site	Data
USGS gage at Hwy. 13 (06179000)	bankfull stage slope----------------- 0.0026% floodplain slope--------------------- 0.002% wetted channel slope----------------- 0.1% Substrata: pool - silt riffle - gravel bank - silty loam, glacial till Ground cover - scattered grasses
McCarty Crossing	length of cross-section--------------2400' height of floodplain above channel--- 4' mean bankfull stage width------------ 127' mean flowing channel width----------- 55' mean depth at bankfull stage: pool---- 5.5' riffle-- 3.0' mean channel depth(water covered)---- 2.0' bankfull stage slope----------------- 0.002% floodplain slope--------------------- 0.002% wetted channel slope----------------- 0.1% Substrata: pool - silt, gravel riffle - gravel bank - silty loamm glacial till Ground cover - grass, low sage, wheat fields
Hagfeldt Slab	length of cross-section--------------1200' height of floodplain above channel--- 2.5' mean bankfull stage width------------ 60' mean flowing channel width----------- 30' mean depth at bankfull stage: pool---- 4.0' riffle-- 2.5' mean channel depth(water covered)---- 3.0' bankfull stage slope----------------- 0.003% floodplain slope--------------------- 0.001% wetted channel slope----------------- 0.1% Substrata: pool - silt, gravel riffle - gravel bank - glacial till Ground cover - low sage, grasses
Ofstedal Slab	length of cross section--------------2000' height of floodplain above channel--- 5.0' mean bankfull stage width------------ 90' mean flowing channel width----------- 30' mean depth at bankfull stage: pool---- 5.5' riffle-- 3.5'

Site

Data

Ofstedal Slab

mean channel depth(water covered)---- 4.0'
bankfull stage slope----------------- 0.0002%
floodplain slope--------------------- 0.0002%
wetted channel slope----------------- 0.1%
Substrata: pool - gravel
riffle - gravel
bank - glacial till
Ground cover - wheat fields, grasses

West Fork Poplar River

South of Peerless

length of cross-section--------------1140'
height of floodplain above channel--- 2.5'
mean bankfull channel width---------- 40'
mean flowing channel width----------- 20'
mean depth at bankfull stage:
pool---- 6'
riffle-- 3'
mean channel depth(water covered)---- 1.8'
bankfull stage slope----------------- 0.0012%
floodplain slope--------------------- 0.001%
wetted channel slope----------------- 0.003%
Substrata: pool - gravel
riffle - gravel
bank - silt, glacial till
Ground cover - low sage, sage, rose bushes

Susag Farm

length of cross-section--------------2000'
height of floodplain above channel--- 1.5'
mean bankfull stage width------------ 60'
mean flowing channel width----------- 60'
mean depth at bankfull stage:
pool---- 6.0'
riffle-- 2.5'
mean channel depth(water covered)---- 1.5'
bankfull stage slope----------------- 0.003%
floodplain slope--------------------- 0.001%
wetted channel slope----------------- 0.1%
Substrata: pool - gravel
riffle - gravel
bank - glacial till
Ground cover - low sage, grass, rose bushes

Main Stem Poplar River

Paulsen Slab above West Fork Confluence

length of cross-section--------------1200'
height of floodplain above channel--- 2.0'
mean bankfull channel width---------- 80'

Site

Data

Paulsen Slab above West Fork Confluence

mean flowing channel width----------- 80'
mean depth at bankful stage:
pool----- 8.0'
riffle--- 3.0'
mean depth(water covered)------------ 2.3'
bankfull stage slope----------------- 0.001%
floodplain slope--------------------- 0.001%
wetted channel slope----------------- 0.1%
Substrata: pool - gravel
riffle - gravel
bank - glacial till
Ground cover - low sage, grass, rose bushes

Crowley Slab below West Fork Confluence

length of cross-section--------------2200'
height of floodplain above channel--- 5.0'
mean bankfull channel width---------- 110'
mean flowing channel width----------- 40'
mean depth at bankfull stage:
pool---- 8.0'
riffle-- 2.5'
mean channel depth(water covered)---- 3.0'
bankfull stage slope----------------- 0.001%
floodplain slope--------------------- 0.006%
wetted channel slope----------------- 0.1%
Substrata: pool - gravel
riffle - gravel
bank - glacial till
Ground cover - scattered sage, grasses rose bushes

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